

On the Road to 100 Gb/s Transmission: Setting the Standard for Next-Generation Enterprise Networks

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IEEE 802.3 Evolution...will it end?

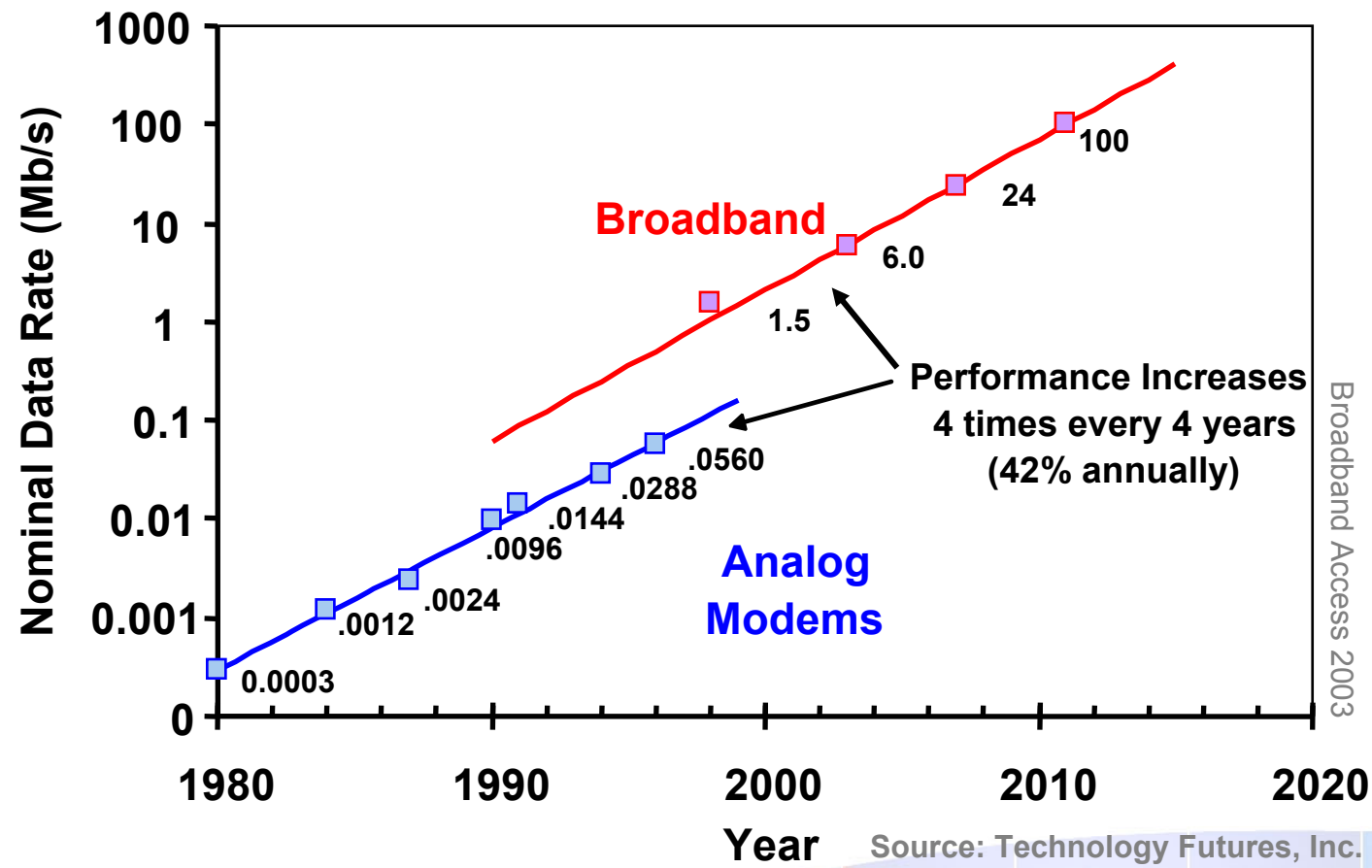
03/1983	802.3	10Base5	10Mb/s over "thick" coax
03/1985	802.3a	10Base2	10Mb/s over "thin" coax (thinnet, cheapernet)
09/1985	802.3b	10Broad36	10Mb/s over CATV
12/1985	802.3c		10Mb/s repeater specifications•
12/1987	802.3d	FOIRL	Fiber Optic Inter-Repeater Link
06/1987	802.3e	1Base5	1Mb/s over twisted-pair (StarLAN)
09/1990	802.3i	10BaseT	10Mb/s over UTP
09/1993	802.3j	10BaseF	10Mb/s over fiber optic
06/1995	802.3u	100Base	100Mb/s over TX:2-pair, T4:4-pair, FX: fiber optic
03/1997	802.3x		Full-duplex operation and flow-control
05/1997	802.3y	100BaseT2	100Mb/s over 2-pairs of Cat-3 UTP
06/1998	802.3z	1000BaseX	GigE over fiber
06/1999	802.3ab	1000BaseT	GigE over twisted-pair
03/2000	802.3ad		Link Aggregation
06/2002	802.3ae	10GBase	10Gb/s over fiber (SR, LR, ER, SW, LW, EW)
06/2003	802.3af		Power over Ethernet
06/2004	802.3ah		Ethernet in the First Mile (EPON)
02/2004	802.3ak	10GBaseCX4	10Gb/s over twin-axial cable - 15m
06/2006	802.3an	10GBaseT	10Gb/s over UTP - 100m
09/2006	802.3aq	10GBaseLRM	10Gb/s over MMF – 220m
	802.3av		10Gb/s over Passive Optical Networks



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Heading to 1 Gb/s per Home by 2020



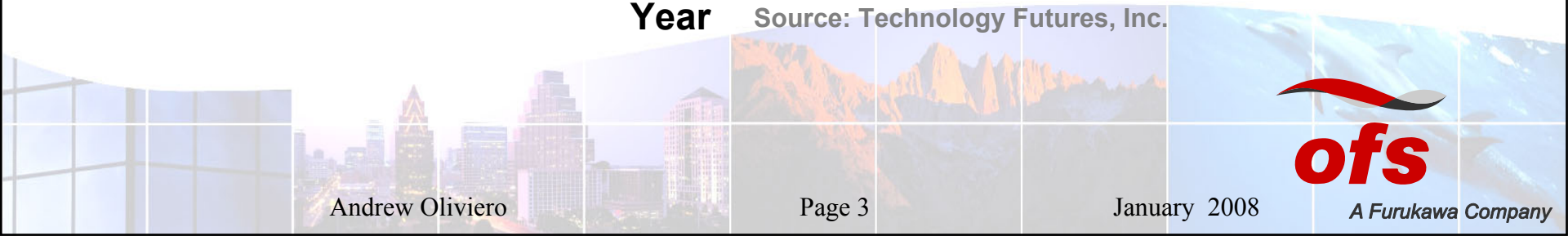
Broadband Access 2003

High Revenue Services

- Entertainment
- Tele-medicine
- Virtual Meetings
- Distance Learning
- Others we can't imagine..

Require High Bandwidth

Source: Technology Futures, Inc.



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Outline

- Market Drivers
- Ethernet Standards Development
 - IEEE
 - HSSG
 - 802.3ba Task Force
- Fiber Considerations
- Opto-electronic Considerations
- Summary

Market Drivers



Drivers for 40 and 100 Gb/s Speeds

Rapid growth of network and internet traffic has placed high demand on the existing infrastructure

❑ Consumers

- Increasing penetration of Triple Play services
- Increasing bandwidth demand
- Personalized Content

❑ Content

- Increasing bandwidth requirements

❑ Networking

- Carriers
- Service Providers
- Internet eXchanges

❑ Private Users

- Supercomputing / High Performance Computing (HPC)
- Data Centers
- Research & Development
- Medical

Digital Photos

HDTV // IPTV // Video-on-Demand

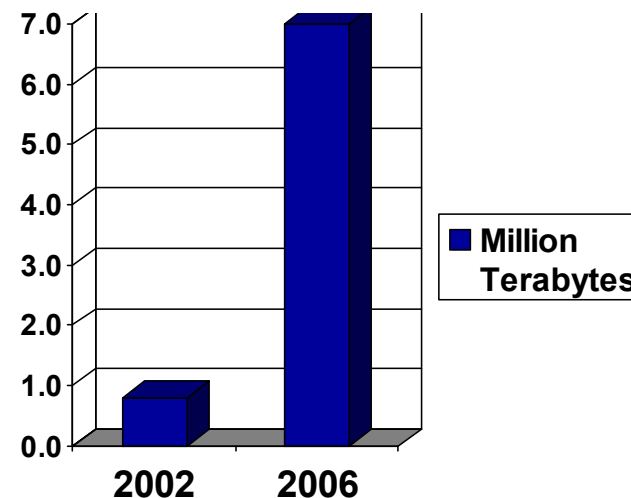
MySpace, YouTube
Gaming

Key Network Points for 40 and 100 Gb/s Speeds

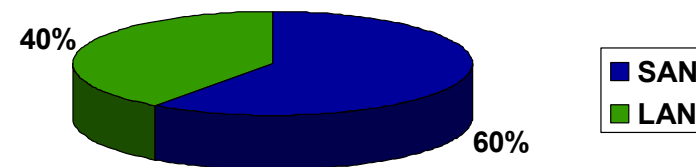
- ❑ **Early deployment of 40 Gb/s Ethernet will support Data Center Servers**
 - Interconnection links
 - Data center servers
 - Storage Area Networks
 - Corporate, video, medical, R&D Enterprises
- ❑ **Early deployment of 100 Gb/s Ethernet will be driven by high-bandwidth switching, routing, and aggregation interconnect points**
 - Metro, core, carrier/service provider networks
 - Internet exchanges and aggregation points
 - Will drive growth of Content Provider applications such as:
 - Video on demand/IPTV/HDTV
 - Gaming
 - Interconnects for high performance super computing environments
- ❑ **Not intended for riser or horizontal building cabling**

Enterprise Data Storage Leading the Way

- **30% annual growth**
 - Last 3 years
 - Predicted for next 5 years
 - ~\$5.3 billion market
- **Largest component of hardware budget**
 - 18% of total I.T. budget
 - 60% of hardware budget
- **Separate LAN/SAN spending strategies**



Enterprise Storage Growth



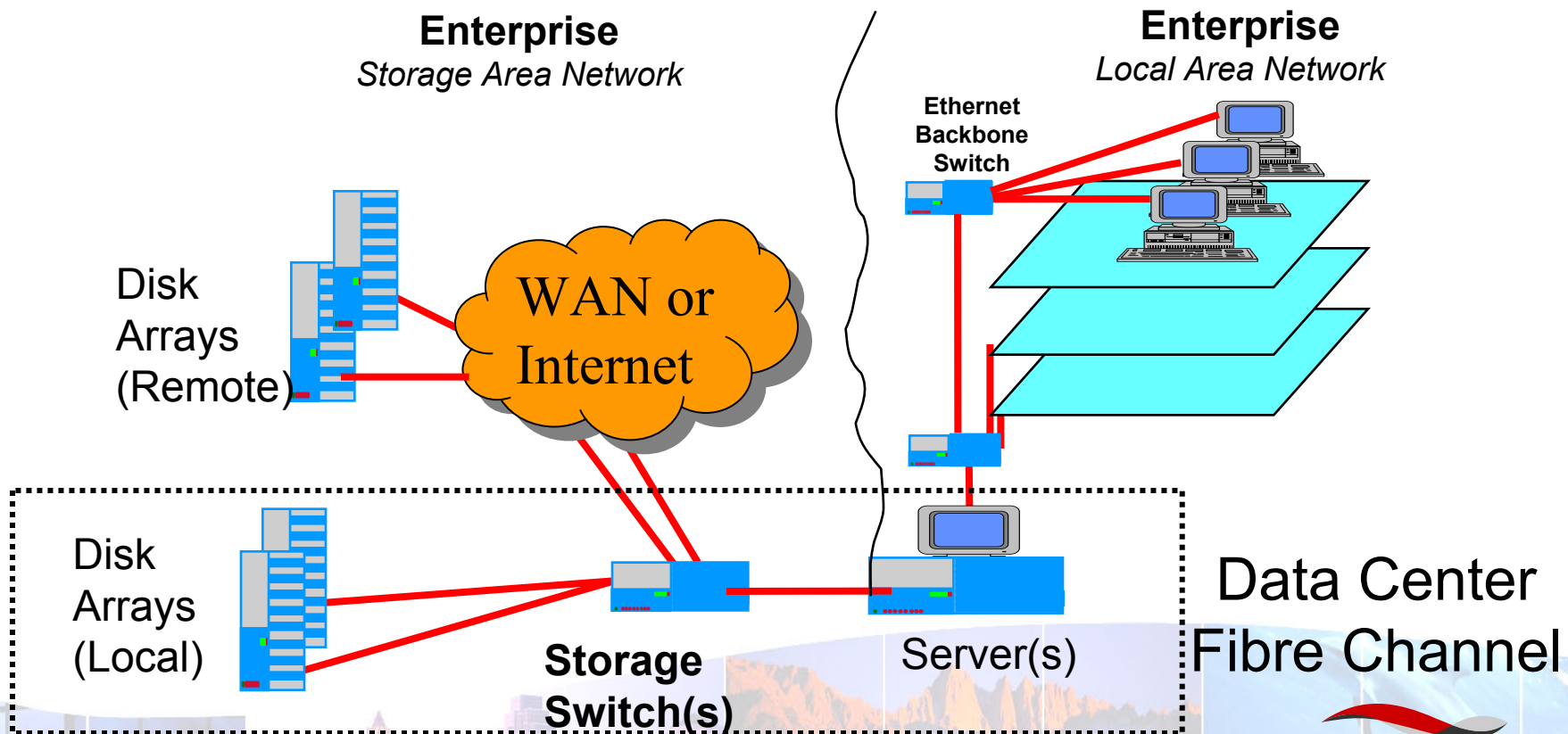
Percent of Hardware Budget

Source: iSuppli Corporation Press Release,

Storage Applications

Fibre Channel

- Most widely deployed storage interconnect technology



Expected Demand

- ❑ Unlike the higher volume end system application typical for 10/100/1000 Mb/s Ethernet
- ❑ Initial volumes for 40 and 100 Gb/s Ethernet are anticipated to be more modest
- ❑ This does not imply a reduction in the need or value of 40 and 100 Gb/s Ethernet to address the stated applications
- ❑ 40 and 100 Gb/s provides a solution for applications that have been demonstrated to need bandwidth beyond existing capabilities

40 and 100 Gb/s Ethernet Standards Development



IEEE-High Speed Study Group (HSSG)

- ❑ **HSSG formed by IEEE 802.3 in 2006**
 - Supported by Fiber Optic and Reach ad hoc committees
 - International representation
 - Component, switch and cabling manufactures
 - End users in public and private sectors
- ❑ **Investigated the need for next Ethernet Speed and recommended objectives for a task force**
- ❑ **Validate 5 Criteria**
 - Broad Market Potential
 - Compatibility
 - Distinct Identity
 - Technical Feasibility
 - Economic Feasibility
- ❑ **Submitted PAR (Project Authorization Request)**

HSSG – 40 and 100 Gb/s Options

- IEEE HSSG (Higher Speed Study Group) voted in July '07 to adopt the following objectives:
 - Support a MAC data rate of 40 Gb/s
 - Provide Physical Layer specifications which support 40 Gb/s operation over:
 - at least 100m on OM3 MMF
 - at least 10m over a copper cable assembly
 - at least 1m over a backplane
 - Support a MAC data rate of 100 Gb/s
 - Provide Physical Layer specifications which support 100 Gb/s operation over:
 - at least 40km on SMF
 - at least 10km on SMF
 - at least 100m on OM3 MMF
 - at least 10m over a copper cable assembly

IEEE 802.3ba Task Force Formed

- Write the standard
 - 2-year effort expected
- Publication of standard by mid-2010
- Set fiber reach
- Set channel specifications
- Set transceiver specifications

Fiber Considerations





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Industry Standard Multimode Fiber Sub-types

Fiber type	Wavelength (nm)	Max Loss (dB/km)	Min Bandwidth (MHz·km)		1 Gb/s Reach (meters)	10 Gb/s Reach (meters)
			OFL	EMB		
62.5 μm (OM1)	850	3.5	200	n.s.	275	33
	1300	1.5	500	n.s.	550	300
50 μm (OM2)	850	3.5	500	n.s.	550	82
	1300	1.5	500	n.s.	550	300
850-nm 10G Laser-Optimized 50 μm (OM3)	850	3.5	1500	2000	1000	300
	1300	1.5	500	n.s.	600	300

OM1, OM2, OM3 =
ISO/IEC 11801 designations

OFL = Overfilled Launch

EMB = Effective Modal Bandwidth
(also known as "Laser" BW)

EMB met by meeting a) DMD specifications, or b) EMBc, as outlined in TIA 492 AAAC-A



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Other Multimode Fiber Sub-Types

Fiber Type	Wavelength (nm)	Max Loss (dB/km)	Min Bandwidth (MHz·km)		1 Gb/s Reach (meters)	10 Gb/s Reach (meters)
			OFL	EMB		
50 μm (OM2+)	850	3.5	700	950	750	150
	1300	1.5	500	n.s.	600	300
50 μm (OM3+)	850	3.5	3500	4700	1040	550
	1300	1.5	500	n.s.	600	300

DMD specifications determined by scaling rules outlined in TIA 492 AAAC-A

OFL = Overfilled Launch

EMB = Effective Modal Bandwidth
(also known as "Laser" BW)

Considerations

□ Short Reach OM3-Multimode Applications

- Short Term → Data Centers
 - At least 100 m over OM3 is the present IEEE objective
 - Typical length between data center panels 60-90 m
 - However, there is long tail in distribution which shows that lengths of 150-250 m should be supported
 - Seeing demand for 200m reach target
 - Further work in the 802.3ba Task Force will finalize lengths
- Long Term → Riser backbones (300m requirement)
 - OM3+ being considered to support up to 300 m
 - ISO could establish an OM4 standard allowing IEEE to reference a new fiber to support longer distances

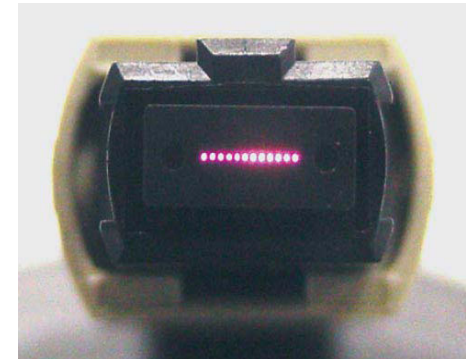
Opto-electronic Considerations



Considerations

□ Short Reach Applications

- **Short Term → Data Centers, HPC's (at least 100m requirement)**
 - Tx mfr's focused on creating lower-cost 850 nm based transceiver arrays for these applications
 - Increase mfg yield by relaxation of spectral width, encircled flux requirements
 - Reduces OM3 length despite readiness of OM3 to support 300m with standard 850nm 10 Gb/s VCSELs



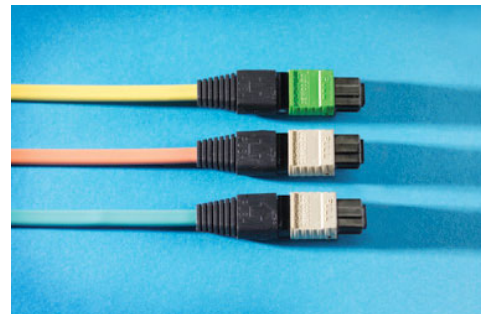
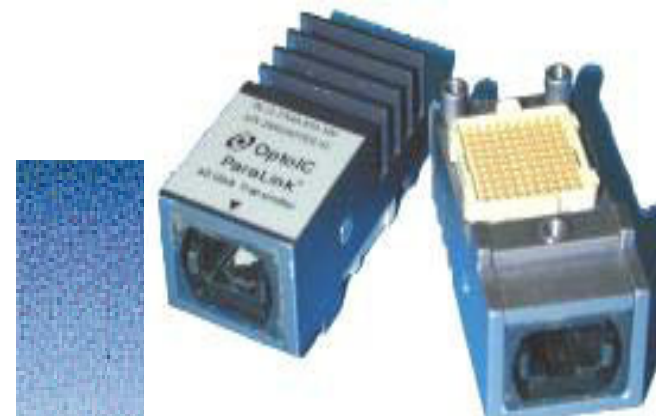
Considerations

❑ Transceiver Considerations

- Will leverage existing fiber and transceiver technologies
 - 850nm Parallel VCSEL Arrays
 - 1310 nm CWDM Transceivers
 - Recommend reading TIA TSB-172

❑ Connectivity Considerations

- MPO cable terminations
- SNAP12 Tx connections





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HSSG Fiber Optic Ad Hoc Proposals

OM3 Multimode

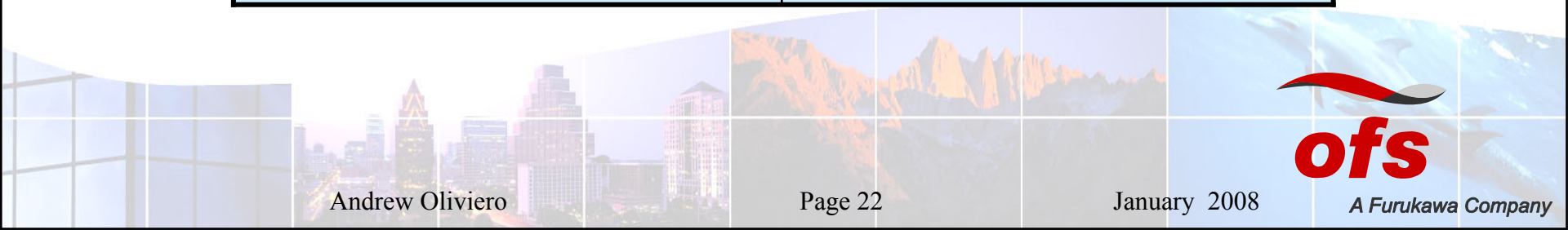
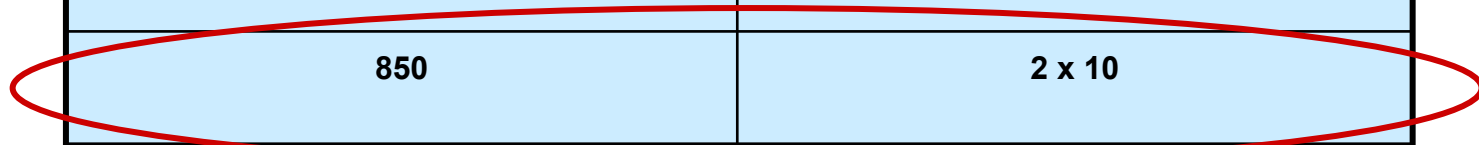
10 Gb/s each over

Multiple Fibers (SDM)

and / or

Multiple Wavelengths (WDM)

Wavelengths (nm)	# Cables x # Fibers
850	2 x 12
850	2 x 10
840 / 860	1 x 12
840 / 860	1 x 10
835 / 850 / 865	1 x 8



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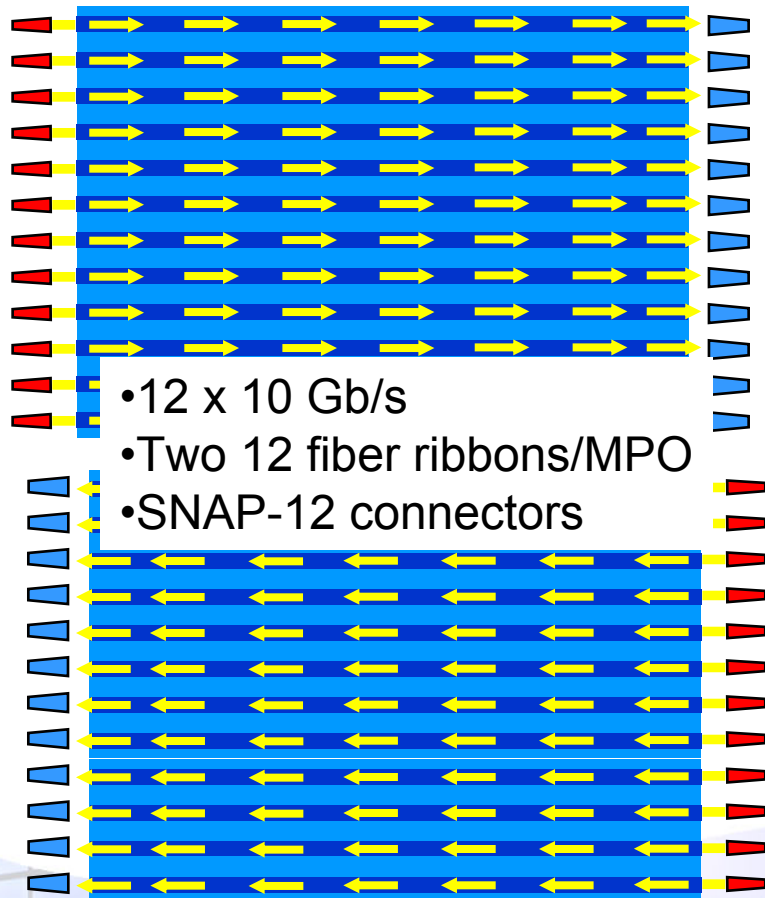
Parallel Systems Technology

Using 850 nm VCSEL arrays for Future Speeds



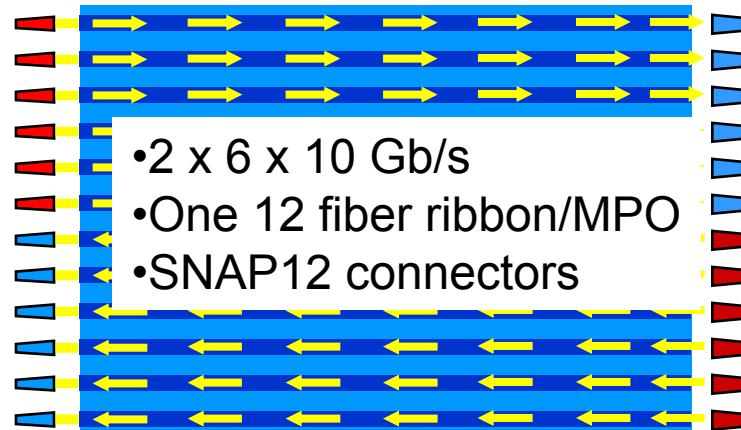
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12 Channel Duplex 100 Gb/s 850 VCSEL Array



- 12 x 10 Gb/s
- Two 12 fiber ribbons/MPO
- SNAP-12 connectors

12 Channel Duplex 2 Lambda



- 2 x 6 x 10 Gb/s
- One 12 fiber ribbon/MPO
- SNAP12 connectors

- Ribbon or loose tube cable
- MPO Connectors
- SNAP12 Tx connectors
- Ideal for Data Center Trunk cabling

***Makes sense to increase density
in Data Center applications.***



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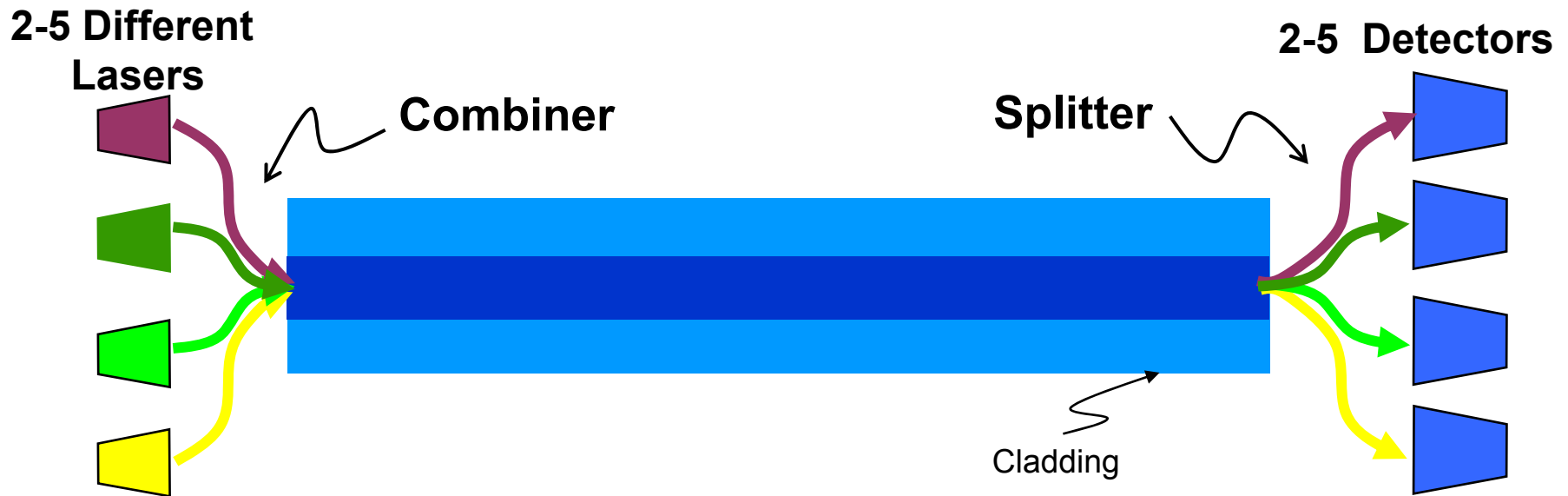
HSSG Fiber Optic Ad Hoc Considerations

Single-mode

Multiple Wavelengths (WDM)

Wavelength Window (nm)	# of Wavelength Channels	Rate (Gb/s)
1550	10	10
1310	5	20
1310	4	25
1310	2	50

CWDM (Coarse Wavelength Division Multiplexing)



- High cost SM packaging, plus more parts and complexity



Cost Implications

❑ Single Mode CWDM Systems

Work continues to define technical and economic feasibility of designs being considered

- Pro: Low cable cost
- Con: High Transceiver cost & development required

❑ OM3 Multimode Parallel Systems

10 Gb/s VCSELS and fiber are already available

- Pro: Low cost, readily available parts
- Con: High cable cost and sensitivity to length

❑ Traditionally, cost of electronics drive cost comparisons between MM and SM



Summary



Conclusions

- ❑ High bandwidth applications and FTTx/CATV triple-play penetration driving need for higher speeds
- ❑ Will support key switching, routing and aggregation interconnect points
- ❑ OM3 multimode will support short reach applications using 850nm based parallel array systems
- ❑ Single-mode will support long reach systems using CWDM technology
- ❑ Publication of 40 and 100 Gb/s Ethernet standard expected by mid-2010